

# REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-02-

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing the collection of information, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Service, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Project Director (0470-0047), Washington, DC 20503.

8 data  
/ other  
ns and  
-0188),

0023

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE		3. REPORT TYPE AND DATES COVERED 01 Apr 00 to 30 Jun 01 FINAL	
4. TITLE AND SUBTITLE (DURIP 00) Exploring the Limits and Applicability of High Precision ICR Technique for Use in Portable Gas Sensors				5. FUNDING NUMBERS 61103D 3484/US	
6. AUTHOR(S) Professor Gabrielse					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Harvard University 1350 Massachusetts Ave Holyoke Center, 4th Floor Cambridge, MA 02138-3826				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NE 801 North Randolph Street Rm 732 Arlington, VA 22203-1977				10. SPONSORING/MONITORING AGENCY REPORT NUMBER  F49620-00-1-0271	
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION AVAILABILITY STATEMENT APPROVAL FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED				12b. DISTRIBUTION CODE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFOSR) NOTICE OF TRANSMITTAL DTIC. THIS TECHNOLOGY HAS BEEN REVIEWED AND IS APPROVED FOR PUBLIC RELEASE LAW AFR 100-12. DISTRIBUTION IS UNLIMITED.	
13. ABSTRACT (Maximum 200 words)  This grant provided equipment that would allow us to explore the limits and applicability of high precision ICR techniques for use in a variety of situations. In fact, we were able to get signals from portable ICR devices. We tried a number of electrode configurations to determine which was the optimum. We learned about some stability challenges that we are still thinking about the trying to devise solutions to. The nature of this grant was to provide equipment that would allow us to do such diagnostics on a continuing basis, at the same time as we were pursuing more fundamental research topics.					
14. SUBJECT TERMS				15. NUMBER OF PAGES	
20020508 077				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT  UNCLASSIFIED		18. SECURITY CLASSIFICATION OF THIS PAGE  UNCLASSIFIED		19. SECURITY CLASSIFICATION OF ABSTRACT  UNCLASSIFIED	
				20. LIMITATION OF ABSTRACT  UL	

## Final Performance Report

AFOSR F49620-00-1-0271

"Exploring the Limits and Applicability of High Precision ICR Techniques  
for Use in Portable Gas Sensors

Gerald Gabrielse  
Professor of Physics  
Harvard University  
[gabrielse@physics.harvard.edu](mailto:gabrielse@physics.harvard.edu)

This grant provided equipment that would allow us to explore the limits and applicability of high precision ICR techniques for use in a variety of situations. In fact, we were able to get signals from portable ICR devices. We tried a number of electrode configurations to determine which was the optimum. We learned about some stability challenges that we are still thinking about and trying to devise solutions to.

The nature of this grant was to provide equipment that would allow us to do such diagnostics on a continuing basis, at the same time as we were pursuing more fundamental research topics. This work is now going on and will continue for some time.

Equipment items are listed with manufacturers, model numbers and prices. Web references are given where this is possible. The nature of the research includes apparatus development. Some equipment items must be custom built because there is yet no commercial supplier. We provided the designs and the construction was done in the Harvard machine shop.

Oscilloscopes (2)	\$13,756
HP 54616C 2 GSa/s 500 MHz 2 Channel Color Oscilloscope with HP 54650A HPIB interface (including shipping and 10% discount)	
Verdi V8 Pump Laser with PE cooler plate option, Coherent Laser Group	\$80,000
PTS D620-R-H-0-2-A-G dual channel frequency synthesizer 620 MHz, 0.1/0.2 Hz resolution, rackmount, OXCO standard, R01240V line, step attenuator, GPIB interface	\$14,051
Magnetic Trap and Dewar System	\$106,622
Hewlett Packard HP 6680A DC power supply, with GPIB, rack mount, bus bars, meter and shipping, with 10% discount. See <a href="http://www.agilent.com">www.agilent.com</a> . \$ 5700	

Ioffe Field Coils: we may need to build these ourselves, but it would be much better to have these built by an experienced manufacturer. American Magnetics Incorporated has just built Ioffe coils for the first time (working with my colleague Prof. John Doyle). Estimated pricing per set of coils is \$15,000. We need 2 sets of coils. \$30,000

Helium temperature dewar system: Because of tight space constraints we

will need to build and assemble this system. Two refrigerator systems (listed below) were purchased as part of this system.

Cryomech: PT405 dual stage pulse tube cryorefrigerator (with shipping)  
\$30,100

PT60 single stage pulse tube cryorefrigerator (with shipping)

See [www.cryomech.com](http://www.cryomech.com). \$12,872

The support and dewar system will be custom designed by us and built for us in the Harvard machine shop. \$27,950

Stanford Research Systems, ICR Electronics \$ 9,401  
Digital delay/pulse generator  
P01622

Vacuum and Gas Handling System \$75,634  
A complete pumping station was constructed by us. Major components are listed.

The following components were purchased at Kurt J. Lesker  
ED-B75302000 Edwards Turbo pump EXT255H DN100 CF \$5431  
ED-A71002909 Scroll Pump, ESDP12, 8.8 CFM \$4777  
ED-B58053160 ACX250H, 24V Air coolers \$ 212  
ED D3916000 EXC120 turbo controller \$1292  
ED D39618030 3 M, Ext to Exc Cable \$ 191  
ED-B580066020 Vent valve, TAV6 \$ 253  
A46226000 EMF10 Filter ET EMF10 \$ 190  
Total: \$ 12,346

The following components were purchased at Granville-Phillips.  
358001-T3 Controller for MICRO-ION Gauge (2 units @ \$950)  
358002 Dual CONVECTRON Gauge module (2 units @ \$395)  
358003 Process control module with 6-relays, 2 relays per channel  
(2 units at \$360)  
358008 3 M long microion cable (2 @ \$100)  
350009 8 M long microion cable (1 @ \$145)  
303030 Dual convection gauge cable, 3 m (1 at \$85)  
303031 Dual convection gauge cable, 7.5 m (1 at \$115)  
275196 Convection gauge on NW 25 (4 at \$150)  
370021 Mount for controllers (1 @ \$50)  
355001 Micro-ion gauge on 2 3/4" conflat (1 @ 235)  
Total \$4840

The following components are made by Granville-Phillips. See [www.helixtechnology.com](http://www.helixtechnology.com).  
Shipping is added.

358001-T5 Granville Phillips Series 358 Micro-Ion Vacuum  
Measurement system (ion gauge, controller,  
Power cord (1 @ \$950)  
355001-YG Micro-Ion gauge (NW35 CF, 2.75 in.) metric (1 @ \$235)  
275196 Convection gauges (NW25KF-welded (2 @ \$150)  
358002 Dual convection gauge module (plugs into ion gauge controller above)

(1 @ \$395)  
 370010 Rack mount on right (1 @ \$50)  
 303031 25 ft cable (controller → convection (1 @\$115)  
 358009 25 ft cable (controller → ion gauge (1 @\$145)  
 358003 Process control option (6 set points) (1 @ \$360)  
 Total \$2550

Kepeco, Inc.  
 BHK1000-0.2 MG power supply (2 @\$1309) \$2618

The remaining items must be constructed by us. Included are the valves, plumbing and cart for the vacuum system. Also included are the high pressure gas handling system, with regulators, gauges, etc. The estimated cost comes from comparing costs for comparable vacuum systems.

Valves, conflat flanges, bolts, tees, etc. and gas handling system \$22,452

Trap electrodes: The Penning trap is the heart of the measurements. One goal is to make Penning trap designs which allow the most robust trap performance. We will design the electrodes, and will get the pieces constructed in our shop.

Penning trap electrodes and enclosure system \$30,828

Computer Workstations \$ 9731

MicroElectronics – CFG10631735 Millenia Max 65133 PC  
 Pentium III 866 MHz, 256 MB RAM, 45 and 30 Gb hard drives,  
 Promise Ultra, ATA100 Controller, GEFORCE@ GTS AGP  
 Graphics card, 19" Trinitron display, MS Office 2000, MS Windows NT,  
 ACS 33 speakers, 3 COM 3C900 PCI combo network card  
 Ref #50560700 \$3161  
 Ref 50561185 \$2970

Dell Computer Corp. – Dell Precision Workstation 330 @ \$3600

RF Amplifiers (we built ourselves from smaller components, and available integrated circuits) \$12,852

AD Interface \$ 9,447

GigaOptics Femtosecond Laser \$49,468  
 GigaJet 30 – 3GHz repetition rate unidirectional Femtosecond  
 Ti:sapphire ring laser kit for user self assembly

Miteq – Low-Noise Amplifiers Au-2A-0110-BNC (20@\$310) \$ 6,203

Berkeley Nucleonics – 4-channel pulse generator w/GPIB, rack mount \$ 2,835  
 110/220V compatible 555-2126

**Total \$390,000**